

P2SAC Highlights

Ray Mentzer, Visiting Professor & P2SAC Executive Director

May 10, 2018

Attendees – May 10

Sponsors

- BP
- Chevron
- Dow
- ExxonMobil
- Fauske & Associates
- Honeywell
- Kenexis
- Lilly
- Phillips 66
- Shell

Guests

- ABS Consulting*
- (aeSolutions*)
- Air Products
- Ashland
- BASF*
- Bechtel
- CCPS*
- CSB*
- Cummins
- Dow AgroSciences
- DowDupont, Corteva*
- Evonik*
- Exponent*
- GlaxoSmithKline*
- Ingredion*
- Kiewit*
- Pfizer
- (Rolls Royce*)
- Siemens*
- SOCMA*
- 3M*

On-going dialog with other Depts:

AAE, ABE, CHEM, IE, IPPH, ME & CV

**denotes 1st meeting*

() last minute cancellation

PhD P2SAC PROJECTS FOR 2017 - 2018

Re-examine current basis for gas and fire detector placement - PI: Prof. Carl Laird

Optimal placement of gas detectors in process facilities: bringing optimization-based gas detector placement into practice (continuing project) - PI: Prof. Carl Laird

Prevention through catalyst design for applications in the petrochemical industry - PI: Prof. Raj Gounder

Robust model-based control for safe pharmaceutical manufacturing - PI: Prof. Zoltan Nagy

Advanced separation techniques for producing rare earth elements and other chemicals from coal fly ash - PI: Prof. N.-H. Linda Wang

Computational analysis of drop coalescence in emulsions to reduce retention times in oil-water separators - PI: Prof. Osman A. Basaran

Chemical Engineering Professional MS Program

- Combines advanced technical education, MBA-level management coursework, and open-ended research project to prepare students for careers in the chemical process industry
- Confers a terminal, non-thesis Masters of Science in Chemical Engineering in 12-months
 - Additional semester may be required, for students without ChE UG degree
- Choose from five areas of specialization: Kinetics, Catalysis, and Reaction Engineering; Biochemical Engineering; Energy System Fundamentals and Processes; Pharmaceutical Engineering; Polymer Science and Engineering
- Students conduct research on a project suggested by an industry sponsor, who agrees to mentor the team with weekly ~30 minute – 1 hour phone calls
 - Students are committed to work ~40 hrs / wk; ~800 hrs for a team of two
 - Work products are a ~20 page written report and presentation (any IP is maintained by sponsor)
- Past Industrial Partners: BP, Dow Chemical Co., ExxonMobil, **Eli Lilly**, **Kenexis**, Air Liquide, Sustainable Polymer Products
- Timeline:
 - Company commitment & project title
 - One page project description: Feb 1
 - Team / project matching: Feb 15 – March 15
 - Research: May 15 – July 31

PMP MS P2SAC PROJECTS

- Quantification of toxicity effects of H₂S ingress into buildings / temporary refuge (Shell)
 - Acoustically-induced vibration of piping systems (ExxonMobil)
 - Utilize industry data to define a schema for process safety applications and then utilize this schema to automate guidance for existing and future PHA studies (Kenexis)
 - A systems engineering approach for managing changes in chemical process R&D labs (Dow AgroSciences)
 - Compilation of thermal hazard safety data for amide coupling reagents (Lilly) – '17
 - Propane hazardous release scenario analysis via CFD (Kenexis) – '17
- **Other cos participating in '18 PMP: Cook Biomedical, Dow, DuPont & Pioneer*

PMP MS P2SAC PROJECTS **Not Pursued**– *cutting room floor*

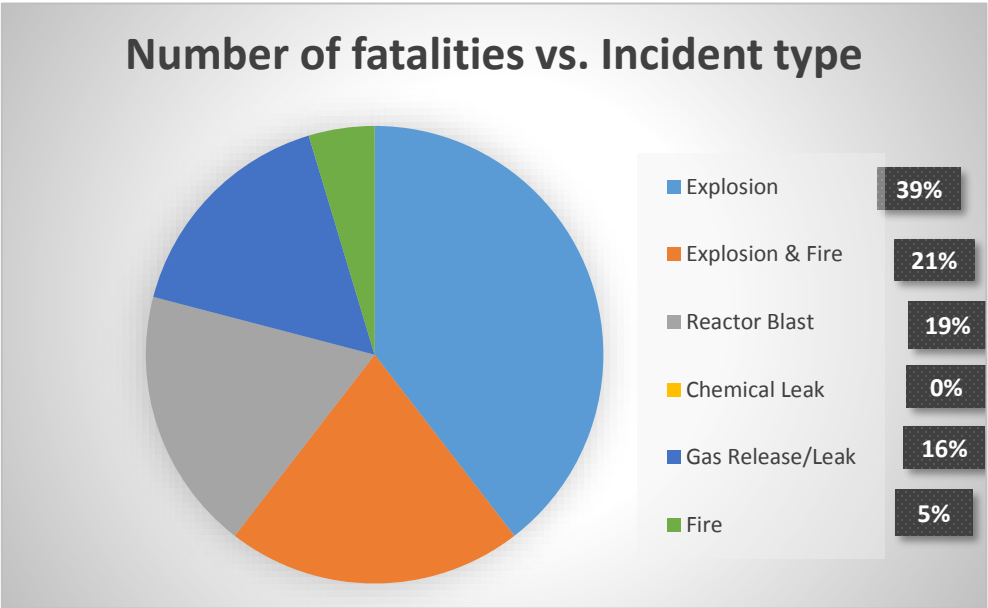
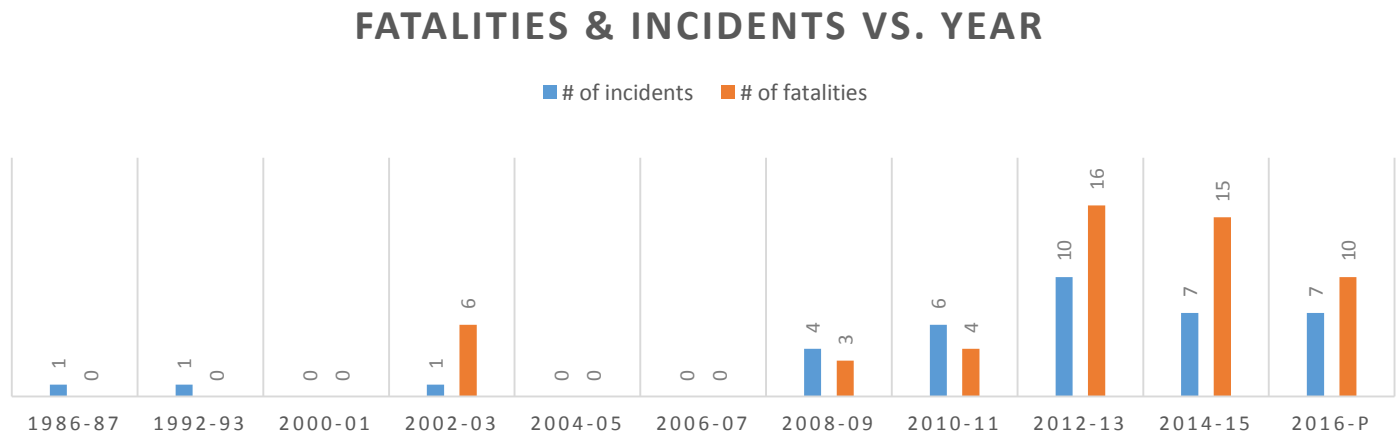
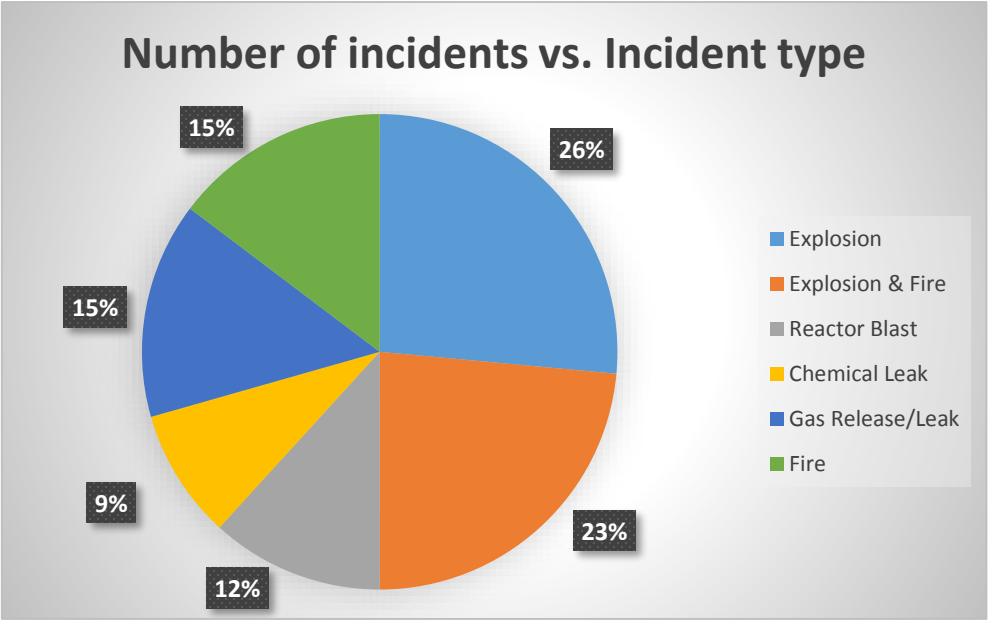
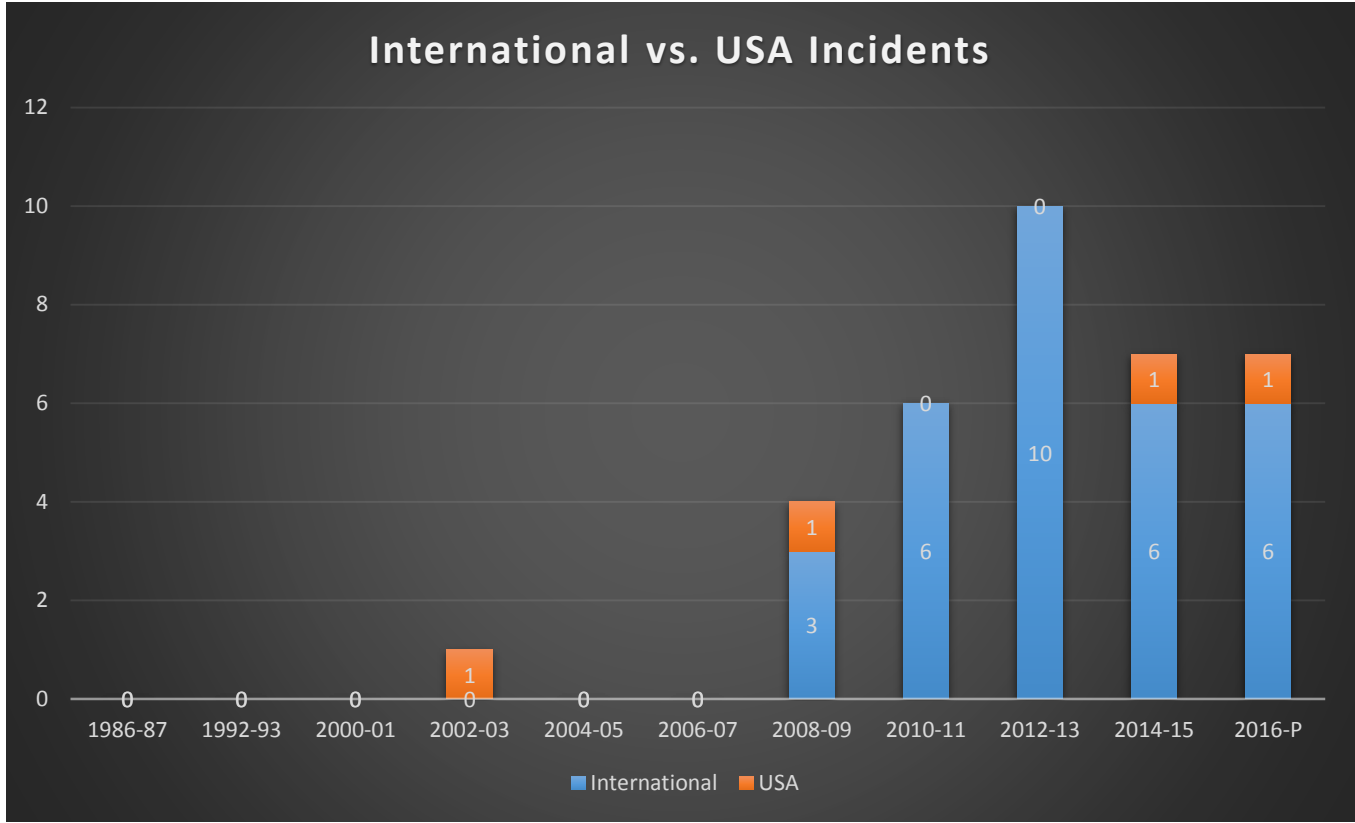
- Computer modeling studies of dynamic simulation of potential overpressure events for the purpose of pressure relief device sizing (ExxonMobil)
- Improved modelling of LNG jet fires (Shell)
- Acquisition of field data for the effect that background radiation has on the effectiveness of optical fire detectors (Kenexis)
- Hazard identification and risk assessment consistency analysis (P66)
- Use of KPIs in process safety (Honeywell)

UG P2SAC PROJECTS FOR 2017 - 2018

- Conduct a benchmarking survey of process safety related incidents in the pharmaceutical industry and industry PSM programs (Lilly)
- Analysis of natural gas pipeline failures (ExxonMobil)*
- Experience with LNG metallurgy failures (ExxonMobil)
- Experience with corrosion under insulation; detection & mitigation (BP)**
- Human factors in design of control rooms for process industries (BP & P66); CHEN 597 class project **

**continuing; **reports on P2SAC web-site*

UG Research – Process Safety Incidents in Pharmaceutical Industry (36)

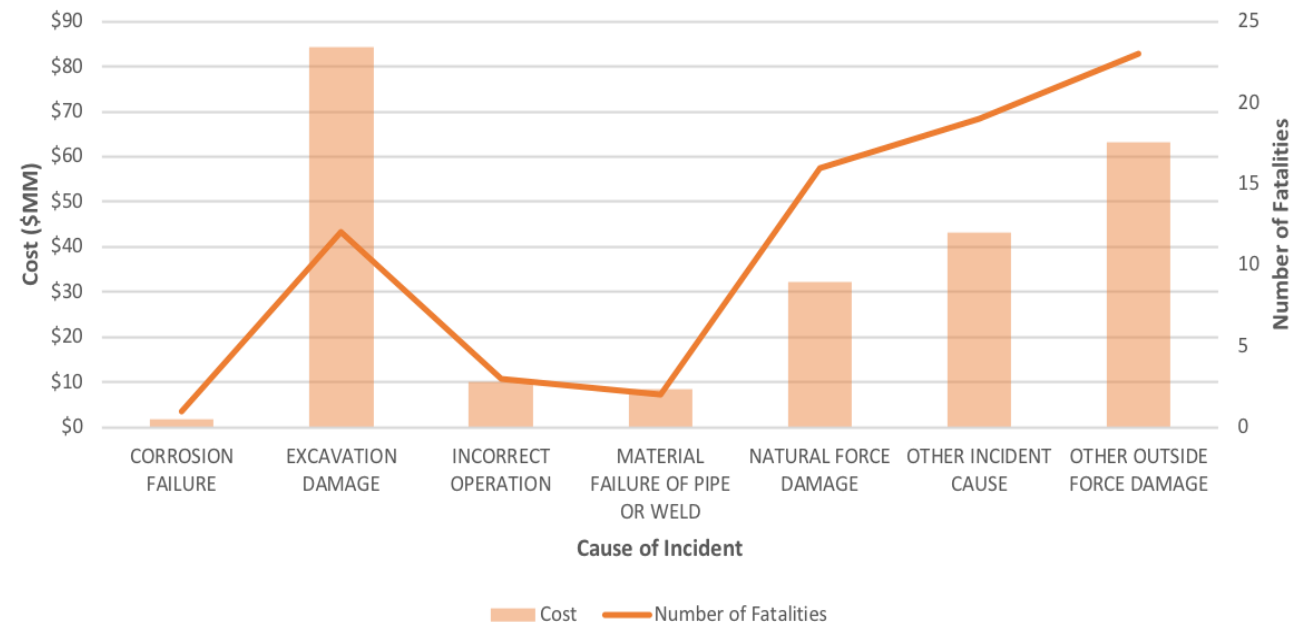


UG Research - Analysis of Natural Gas Pipeline Leaks (PHMSA data)

Transmission: Cause of Incident (2010 to Present)



Distribution: Incident Cost (USD) and Fatalities (2010 to Present)



Proposed P2SAC Research Projects

Modeling

- Re-examine current basis for gas & fire detector placement (BP); PhD Laird
- Validate large scale consequence modeling (BP); MS (Kenexis sponsor)
- Re-examine common cause models (BP, Honeywell)

Metallurgy / Corrosion

- Experience with LNG metallurgy failures (ExxonMobil); UG research
- Experience with corrosion under insulation and detection methods (BP); UG research
- Risk and reliability of aged gas and product pipelines (ExxonMobil, Laird); UG research
- Extend Charpy impact curves for brittle fracture of pipelines to different metallurgies (ExxonMobil)

Pharmaceutical

- Conduct a process safety related benchmarking survey of the pharmaceutical and perhaps broader industries (Lilly); UG research
- Compilation of thermal hazard safety data for amide coupling reagents (Lilly); MS (Lilly sponsor)
- Small-scale predictive tool for combustible dust prediction (Lilly)
- Develop a 'Safety by Design' concept incorporating lot-to-lot variability of reagents or solvents (Lilly)

Human Factors

- Human Performance of Control Room Operators (BP & ExxonMobil)
- Personnel competence in the major hazards industry (Phillips 66)
- Analysis of how past engineering design criteria accounted for normal human error mechanisms (Phillips 66)

Other

- Impact of modern personal electronic devices as potential ignition sources in process areas (ExxonMobil)
- Address validation of the use of water sprays to mitigate overpressures (ExxonMobil)
- Technology to detect subsea leaks (BP)

Faculty

- Computational analysis of drop coalescence in emulsions to reduce retention times in oil-water separators (Prof Basaran); PhD
- Develop strategies to make chemical processes inherently more cyber physically secure (Prof Pekny & Eric Dietz)
- Erosion in pipelines (Prof Basaran)
- State of the art battery design offering enhanced safety while yielding equivalent capacity as Li at higher potentials. (Prof Pol)

*Red represents portion of '17 research program

'Engineering.purdue.edu/P2SAC'



Purdue Process Safety and Assurance Center

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Purdue Process Safety & Assurance Center

Each year, people around the world lose their lives due to the lack of proper training and recognition of chemical process safety. These incidents also result in injuries and environmental and facility damage. Although international recognition of the importance of chemical process safety is growing, only a few centers of expertise exist.

The Purdue Process Safety & Assurance Center (P2SAC) plays a key role in saving lives, and educating students on process safety, preparing them to address potential disasters, and equipping them for success when entering industry. Not only does P2SAC educate students on the highly technical nature of 'process' safety vs. 'personnel' safety, but it also serves as the hub for:

- Conducting cutting-edge, fundamental science-based research with experimental and theoretical modeling;
- Creating and teaching undergraduate and graduate process safety courses, and instilling Process Safety Management (PSM) awareness in core capstone design projects; and
- Providing a source of expertise for industry and other stakeholders regarding process safety-related standards and best practices.

P2SAC is uniquely focused on manufacturing and consumer products, including the oil & gas, chemical, pharmaceutical and technology industries. The research projects conducted at the center are solicited from industry sponsors, government research labs and academia.

P2SAC faculty are engaged in, and knowledgeable about various facets of process safety that enhance the educational experience of all Purdue Chemical Engineering students, and ultimately help to improve the safety of our world.

CHEN 420 / 597- Chemical Process Safety – core UG course

Personnel vs. Process Safety & Metrics

Applicable regulations: OSHA
PSM, EPA RMP, etc

Source Term Modeling

Toxicants & Industrial Hygiene

Toxic/Flammable Gas Release

Dispersion Modeling

Fire & Explosion Protection

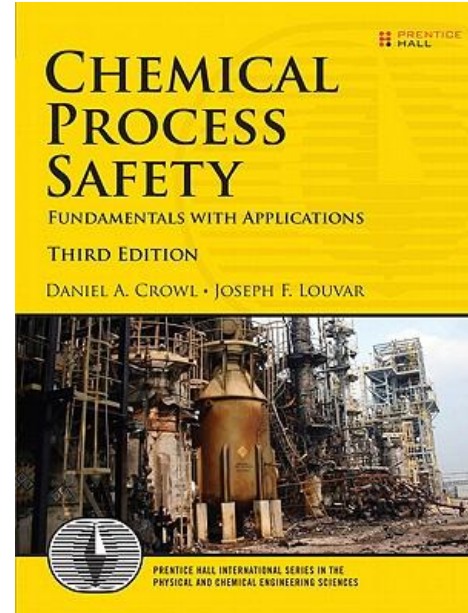
Chemical Reactivity

Relief System Design

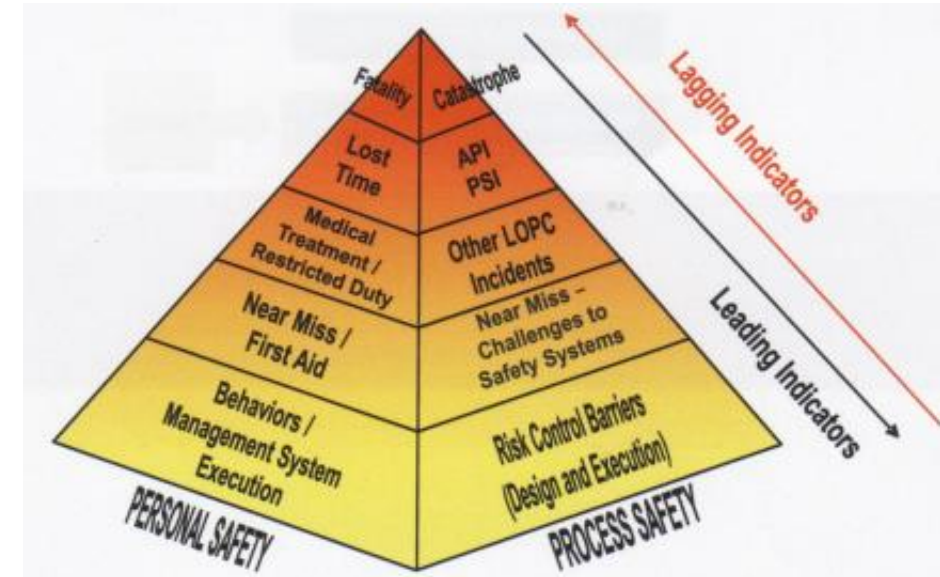
Hazards Identification (HAZOP, ..)

Risk Assessment (Matrix, QRA, ..)

Accident Investigations



Process Safety Metrics



Typical 4x4 Risk Matrix

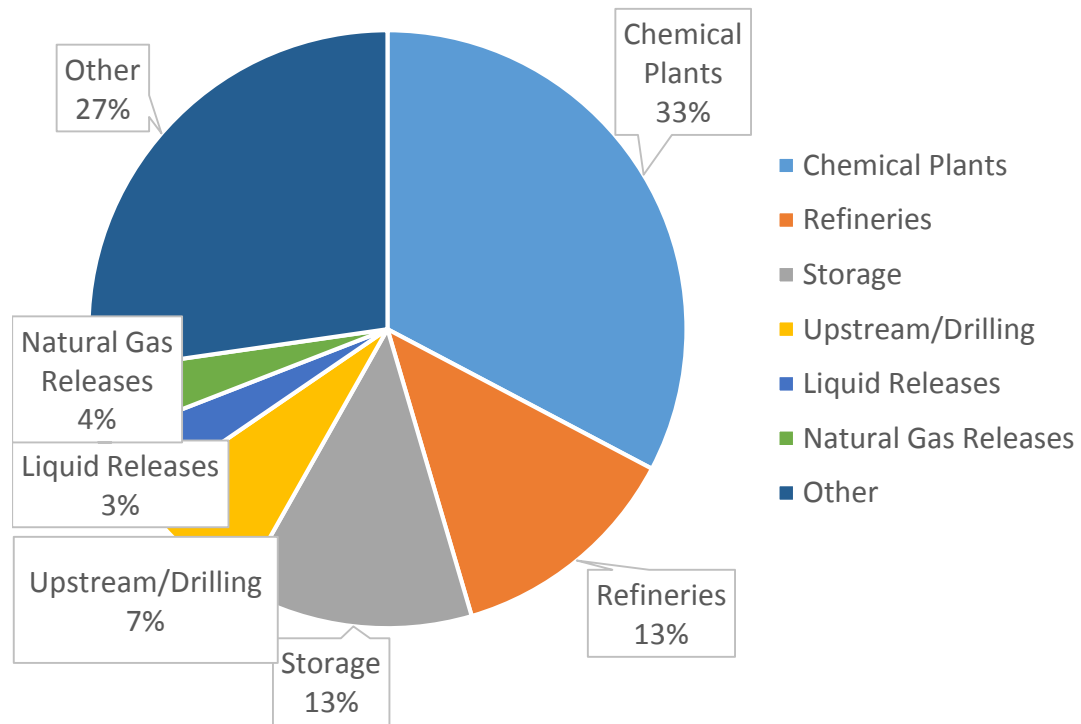
		Likelihood			
		Frequent	Possible	Rare	Remote
Severity	Major	Very High	Very High	High	Moderate
	Serious	Very High	High	Moderate	Low
	Minor	High	Moderate	Low	Low
	Incidental	Moderate	Low	Low	Low

Fundamental Equation for Neutrally Buoyant Gas Dispersion

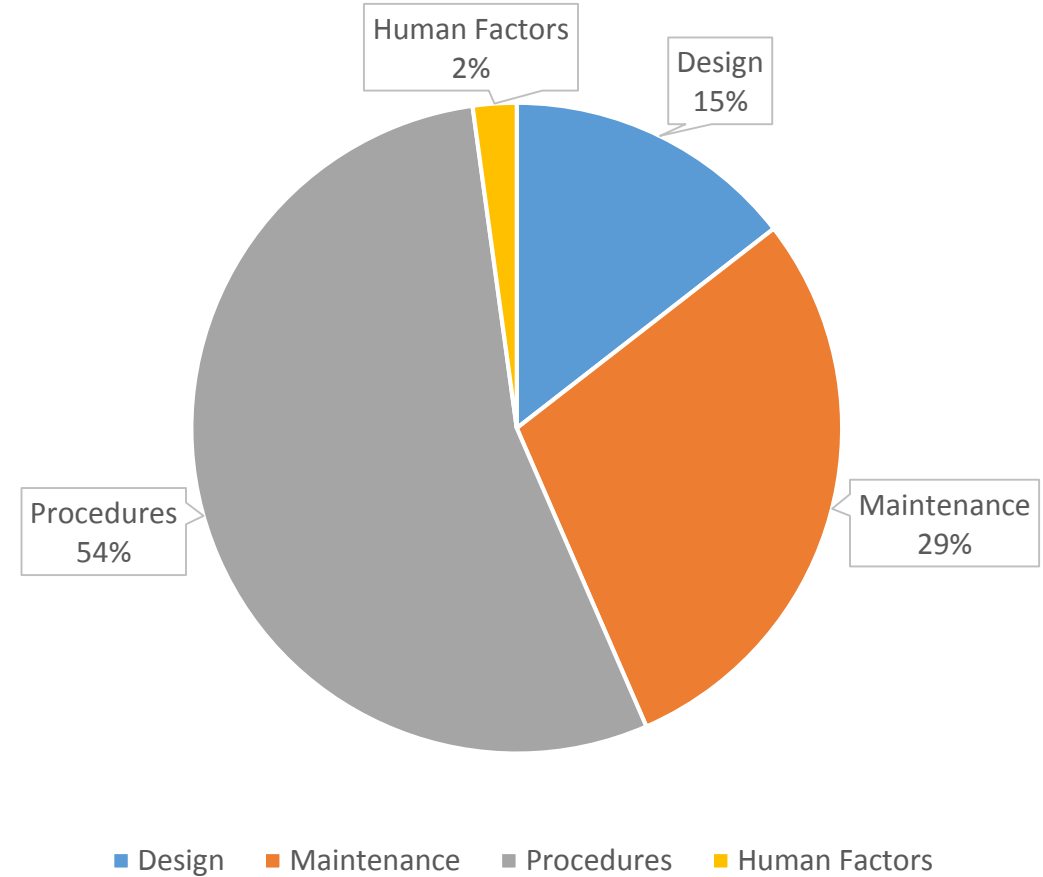
$$\frac{\partial \langle C \rangle}{\partial t} + \langle u_j \rangle \frac{\partial \langle C \rangle}{\partial x_j} = \frac{\partial}{\partial x_j} \left(K_j \frac{\partial \langle C \rangle}{\partial x_j} \right)$$

Summary of CHE 420 / 597 Incident Analyses (56 incidents)

Incidents per Type of Operation



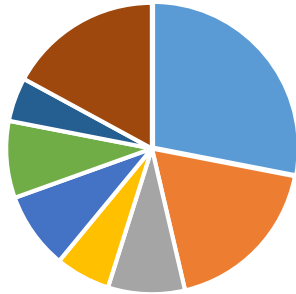
Incident Root Causes



CSB* Incident Investigations '98 – '15

- 88 investigations / 171 fatalities -

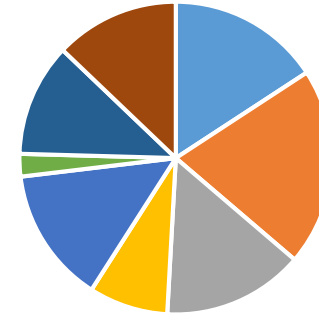
Incidents per Industry



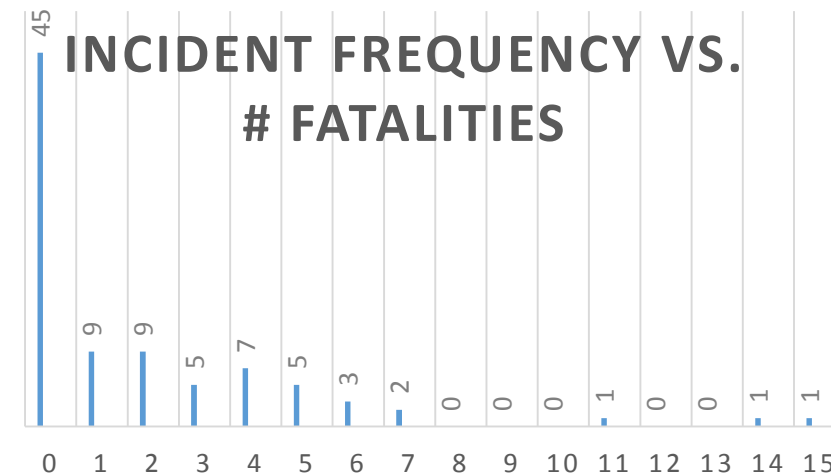
- Chem Plant (23)
- Refining (15)
- Manufacturing (9)
- Processing non-O&G (9)
- Agriculture / Food (7)
- Storage / Blending (5)
- O&G Prod (4)
- Other (14)

Other – hazardous waste & wastewater treatment, medical / pharmaceutical, laboratories, gas pipeline, rail car loading,...

Fatalities per Industry



- Chem Plant (27)
- Refining (35)
- Manufacturing (25)
- Processing non-O&G (14)
- Agriculture / Food (24)
- Storage / Blending (4)
- O&G Prod (20)
- Other (22)



*US Chemical Safety Board

Questions?

Thanks to our P2SAC Sponsors !

